UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON

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SPECIFICATION FOR KNOOP INDENTERS

(April 1, 1946)

I. INTRODUCTION

The Knoop indenter was developed at the National Bureau of
Standards and described in Research Paper 1220, "A Sensitive
Pyramidal-Diamond Tool for Indentation Measurements" by Frederick
Knoop, Chauncey G. Peters, and Walter B. Emerson. Research Paper
1220 is part of the Journal of Research of the National Bureau of
Standards, Volume 23, No. 1, July 1939.

The Knoop indenter can be used to determine hardness numbers
of a wide range of materials although it appears to be most useful
in the investigation of brittle materials such as glasses, hard
carbides and oxides, thin layers of metals and small samples.

The indenting surfaces of the indenter are four planes produced
on a diamond which is secured in a suitable mount. The lines of
intersection between adjacent planes form the edges of the
indenter. The four edges of the indenter intersect very nearly at
a point on the axis of the indenter. An indentation viewed
normally to the specimen surface appears rhombic in outline with
one diagonal perpendicular to and about seven times the length of
the other. The depth of the indentation is about one-thirtieth
the length of the longer diagonal. The indentation number is
defined as the indenting load in kilograms divided by the pro-
jected area of the indentation in square millimeters.

It has been determined from a large number of tests that the
resistance of the indenter point to fracture is greatest when an
octahedral diamond is used having one crystallographic axis
parallel to the axis of the indenter mount. For this reason it
is necessary to specify the type of diamond and its orientation.

II. DEFINITIONS

1. INCLUDED EDGE ANGLE

An included edge angle is the included angle between opposite
edges of the indenter.

2. OFFSET

The offset is the length of the line of intersection of
opposite plane faces of the indenter caused by the failure of all

four plane faces to intersect at a point.

3. INDENTER CONSTANT

The indenter constant is the ratio of the projected area of the indentation to the square of the length of the long diagonal. Its value is given by the formula

$$C = 1/2 \text{ cotangent}(A/2) \text{ tangent}(B/2)$$

where: A = Included longitudinal edge angle
        B = Included transverse edge angle

4. INDENTATION NUMBER

The indentation number is defined by the relation

$$I = \frac{P}{L^2 C}$$

where: I = Indentation number
        P = Indenting load in kilograms
        L = Length of long diagonal in millimeters
        C = Indenter constant

Note: It is convenient to determine indentation numbers from tables which have been computed for an indenter having the standard longitudinal edge angle of 172° 30' and the standard transverse edge angle of 130° 0'. The constant for such an indenter is 0.07028. The constant for an indenter complying with this specification may differ from 0.07028 by not more than one percent.

III. REQUIREMENTS

1. GENERAL

A Knoop indenter shall consist of a pyramidal diamond indenting tool secured in a mount of suitable shape and material. The diamond shall be a well formed octahedron free from carbon spots and flaws. One crystallographic axis shall be parallel to the axis of the indenter mount to within 5 degrees. The longitudinal edges shall be parallel to within 5 degrees to a plane containing that crystallographic axis and one of the other crystallographic axes. The mount shall be symmetrical about an axis which passes through the vertex of the indenter and is perpendicular to the base of the mount. The end of the mount opposite the indenter shall be counterbored and shall have a tapped hole concentric with both the counterbore and axis.

2.   MOUNTING

   (a) The distance from the vertex of the indenter to the
       base of the mount shall be 0.85±0.10 inch.

   (b) The diameter of the counterbore shall be 0.376±0.001 inch.

   (c) The depth of the counterbore shall be 3/32±1/32 inch.

   (d) The outside diameter of the mount at the counterbored
       end shall be 0.500(+.100, -.020) inch.

   (e) The mount shall be tapped with a 10-32 thread, 1/2 inch
       deep, loose fit (Class 1) and countersunk to leave not
       less than 10 full threads.

   Note: The base of the mount should be smooth and flat to
permit repeatable measurements of the half angles.

3.   INDENTER

   (a) Each longitudinal edge shall be not less than 0.7 mm
       in length.

   (b) Each transverse edge shall be not less than 0.5 mm in
       length.

   (c) The vertex of the indenter shall be not more than
       0.01 in. distant from the normal to the center of the
       base of the indenter.

   (d) The offset shall not exceed 3 microns.

   (e) The included longitudinal edge angle shall be not less
       than 172° 25' and not more than 172° 35'.

   (f) The constant for the indenter shall differ from the
       constant for an indenter having standard angles by
       not more than 1.0 percent.

   (g) The angles between a perpendicular to the base of the
       indenter and the two longitudinal edges shall differ
       by not more than 14 minutes of arc. The angles between
       a perpendicular to the base of the indenter and the two
       transverse edges shall differ by not more than 20
       minutes of arc.

   (h) The longitudinal edges shall be free from nicks greater
       in length than 0.5 micron for a distance of 125 microns
       from the point. From 125 microns to 1000 microns or a
       distance equal to the length of the shorter longitudinal
       edge, whichever is the smaller, the ratio of the length
       of any nick to its distance from the point shall not
       exceed 0.004.

IV.   METHODS OF TEST

1.   PROOF LOAD

Each indenter, before inspection, shall be proof loaded to 5 kg on a sample having an indentation number not less than 700.

2.   DIMENSIONAL TOLERANCES

Dimensional tolerances shall be checked by standard gaging methods.

3.   EDGE ANGLES

The edge angles shall be measured with a sine bar or other suitable device so used that the error of measurement shall not exceed one minute of arc.

4.   NICKS AND OFFSET

The longitudinal edges of the indenter shall be inspected for nicks and offset by viewing indentations made with the indenter in a polished steel block.

V.   METHOD OF REPORTING RESULTS

1.   CERTIFICATES

For an indenter which complies with the requirements of this specification a certificate will be issued giving the values of the included edge angles.

2.   REPORTS

For an indenter which fails to comply with the requirements of this specification a report will be issued stating wherein the indenter fails to comply.